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Technical Note 2-63

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SUMMARY OF STUDIES CONDUCTED WITH THE AR15 (U)

James P. Torre, Jr.

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January 1963

HUMAN ENGINEERING LABORATORIES

ABERDEEN PROVING GROUND,
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9 Technical Note 2-63

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10 James P. Torre, Jr. 14 TN-2-63

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ABSTRACT

This report contains a summary of firings conducted with the AR15 using several muzzle brake deflectors and other means to reduce automatic fire dispe. sion.

SUMMARY OF STUDIES CONDUCTED WITH THE AR15 (U)

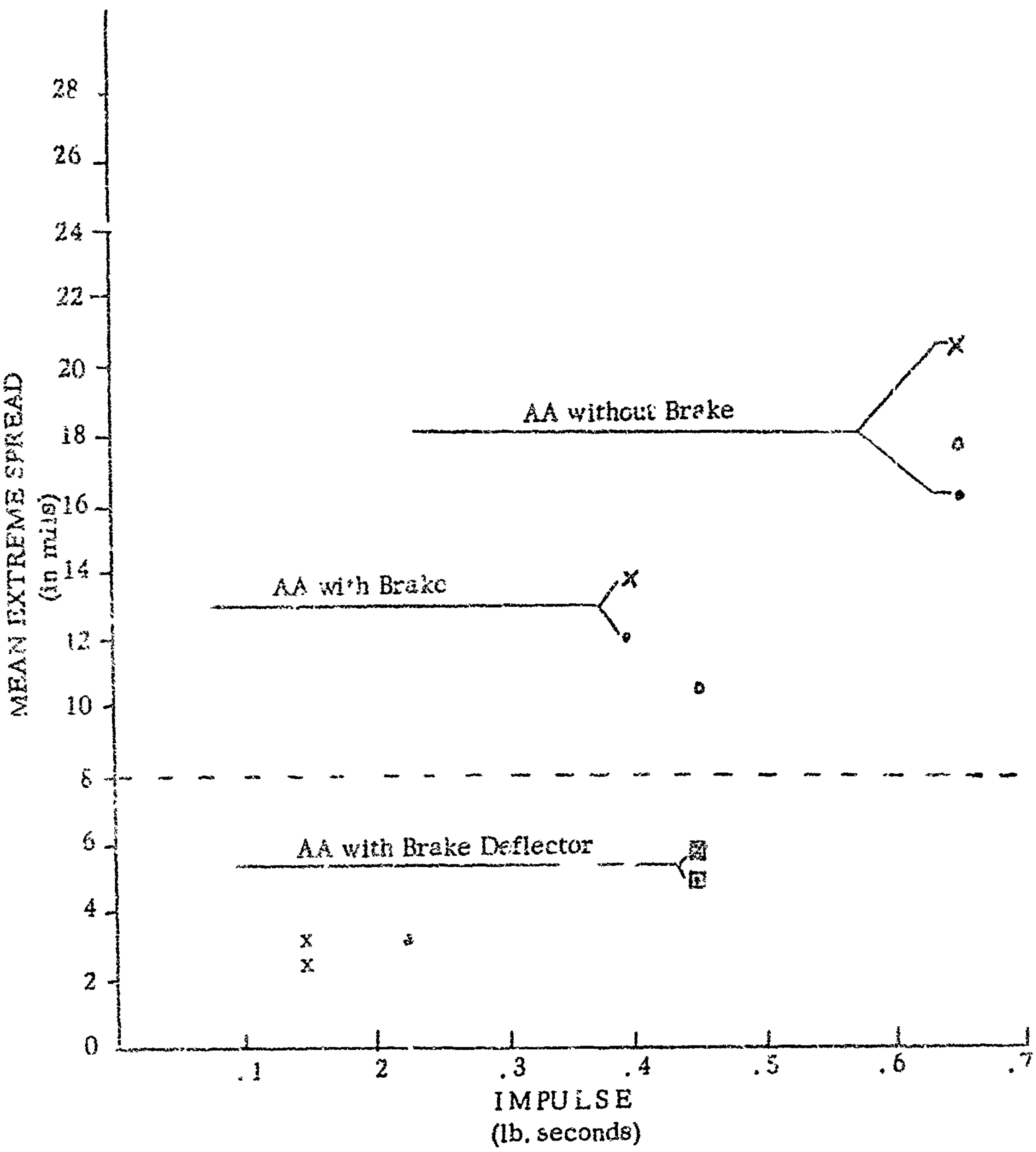
(C) During the past years several small arm studies were conducted investigating the effects of rifle design parameters on dispersion when firing three-round bursts automatically. These studies were conducted in support of the Special Purpose Individual Weapon (SPIW) feasibility program.

(C) The purpose of conducting these studies was not only to establish relationships between three-round dispersion and rifle design parameters, but also to determine what combination of rifle design parameters would meet the requirements for the SPIW program specified by Ballistic Research Laboratories (BRL). In general, these requirements for a burst of three rounds can be stated as follows:

a. The three rounds should be circularly, normally distributed with a 2- to 3-mil (m̸) linear standard deviation about the aim point.

b. Or, if serially fired, the average extreme sp ad of the three rounds shall be 4 to 5 m̸.

(C) Using different test rifles, one of which was the Aircraft Armaments flechette rifle with a muzzle brake deflector, the effects on dispersion of impulse, stock configuration, cyclic rate, and a muzzle-brake deflector were determined. These results are presented in Figure 1 for one stock configuration. It will be noted that the requirements for the SPIW could be met by reducing impulse sufficiently or nearly met through the use of a muzzle-brake deflector. It was noted at the time that the Aircraft Armaments weapon without a muzzle brake produced an impulse of .65 lb-sec; with a muzzle brake, the impulse was reduced to .39 lb-sec. However, by reducing the braking action to .45 lb-secs and by deflecting some of the gases upward, less dispersion resulted. It appeared as though a serially fired SPIW system would require a muzzle-brake deflector in order to meet the optimum requirements established by BRL. Although Figure 1 deals with impulse values of less than 1.0 lb-sec, in order not to overlook the possibility of increasing the effectiveness of a current conventional system, it seemed appropriate to examine conventional weapons of higher impulse, with the thought of reducing their impulse to something less than 1.0 lb-sec, and also incorporating a deflection component into the muzzle brake.



h = 0 (straight stock)
. = 2500 rounds per minute
x = 1900 rounds per minute
o = 1200 rounds per minute
☒ = 1900 rounds per minute
☒ - 2500 rounds per minute

Fig. 1. Means for Five Expert Shooters

(C) A cursory look at the current rifles soon eliminated the M14, Carbine, and other high-momentum systems for the following reasons:

a. Their impulse was high -- 2.65 lb-sec for the M14, and 1.18 lb-sec for the Carbine.

b. Their projectile weight to propellent weight ratios were 3 to 1.

(C) Thus the most that could be hoped for in the way of a reduction for the M14 for a 90° gas reversal was the order of 2.0 lb-secs; even a 180° reversal of gases, which would be unacceptable from the shooter's standpoint, would still produce an impulse of approximately 1.4 to 1.6 lb-sec.

(C) The AR15 was the weapon chosen, for the following reasons:

a. It is a low momentum weapon (1.16 lb-sec), with a projectile to propellent-weight ratio of 2 to 1.

b. Further, its lethality was comparable to the M14.

(C) Two muzzle brakes for a .30 caliber weapon were available. One was a muffler-type of unsymmetrical design which needed little testing before it was shown unsatisfactory. The second, shown in Figure 2, was modified to reduce the caliber from .30 to .22. It proved uncomfortable to fire because of the high noise level and angle at which the gases were diverted. The Human Engineering Laboratories then designed and developed two brakes, the first of which is shown in Figure 3. This was the baffle-type, non-symmetrical to allow an upward and to-the-right gas deflection, in order to provide a down and to-the-left force component. This brake did not allow one to vary the deflection component of the gas diversion. Later, two holes were drilled out of the base and four plugs made. Two plugs were solid and the other two hollow. In this way the amount of deflection could be regulated by removing the plug either entirely or in part. Finally, a variable muzzle brake was designed and developed (Fig. 4). This design permitted one to vary both the amount of braking and deflecting. The ports were 90° to the bore axis, since it was felt that diverting the gases beyond 90° would cause discomfort to the shooter. Measurements of the muzzle-brake characteristics indicated that with all ports open -- thus no deflection -- it reduced the impulse from 1.16 lb-sec to .77 lb-sec. Theoretically, with a 90° diversion of all the gases, .79 lb-sec is the limit. It was found that the design diverted the gases beyond 90° to somewhere in the order of 105°, thus accounting for the additional efficiency. The variable muzzle brake produced the smallest dispersions with the least discomfort.

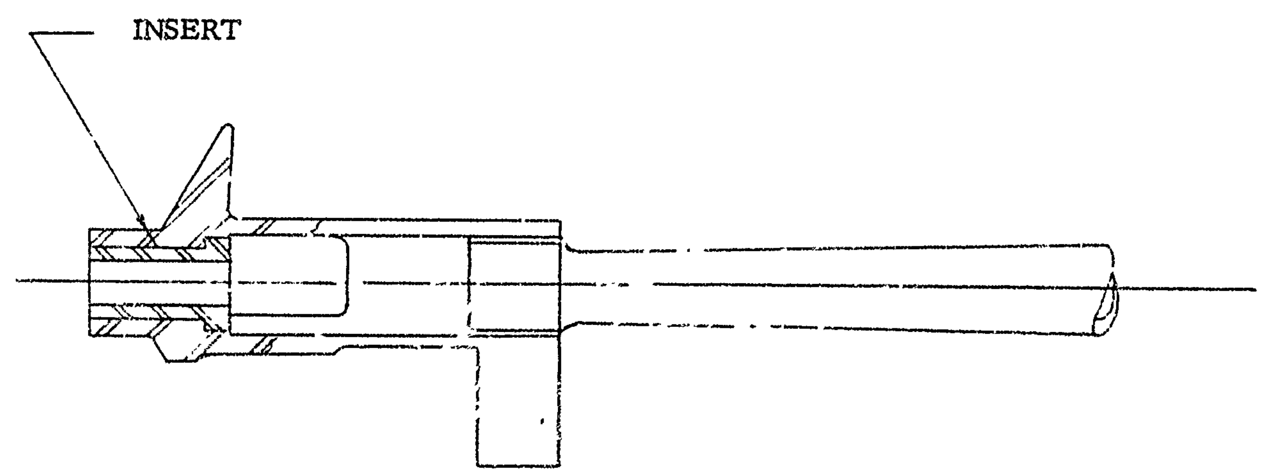


Fig. 2. Modified Muzzle Brake
Cal. .30 to Cal. .22
(Scale - Full)

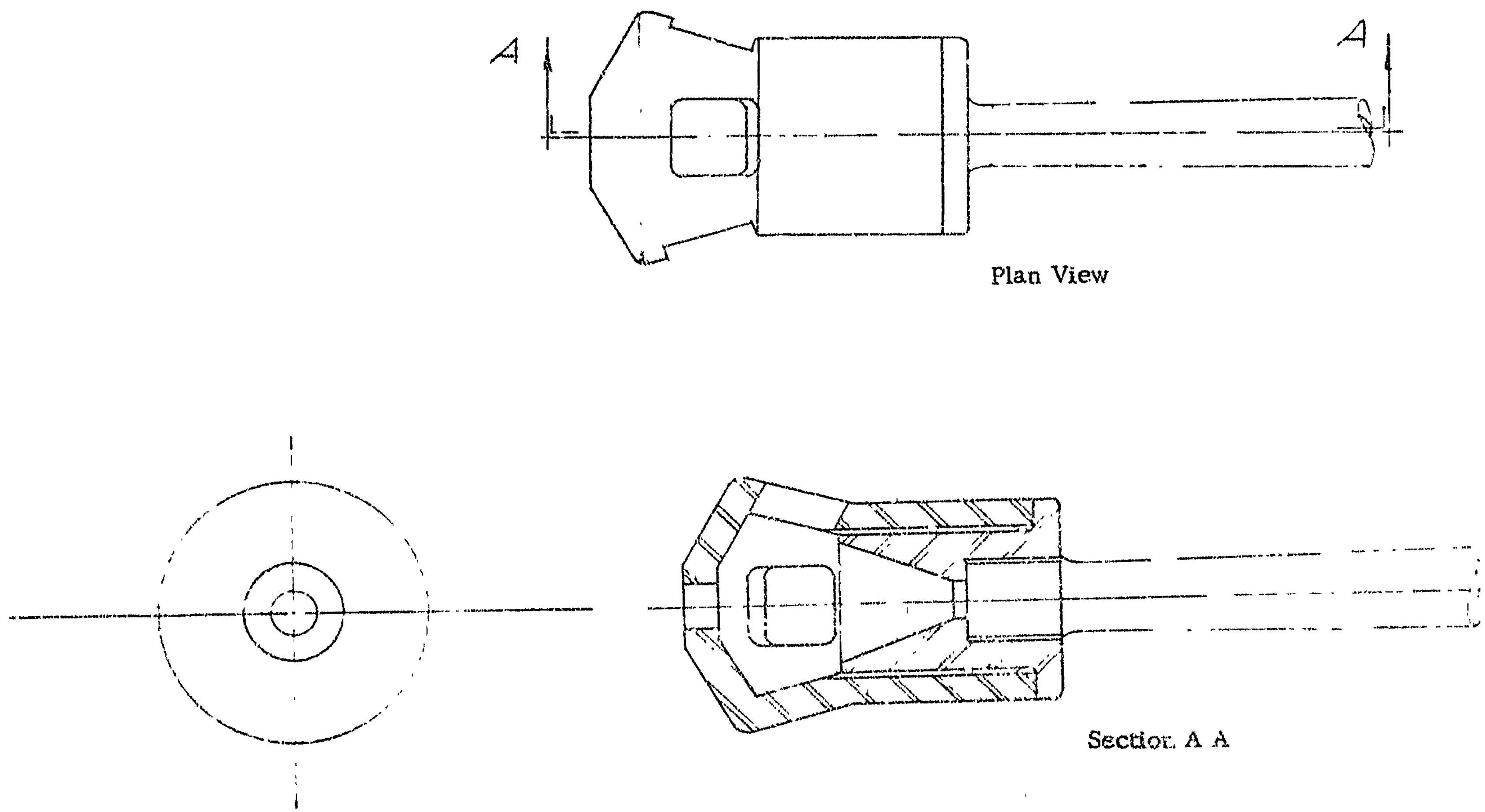


Fig. 3. Experimental Muzzle Brake
(Scale · Full)

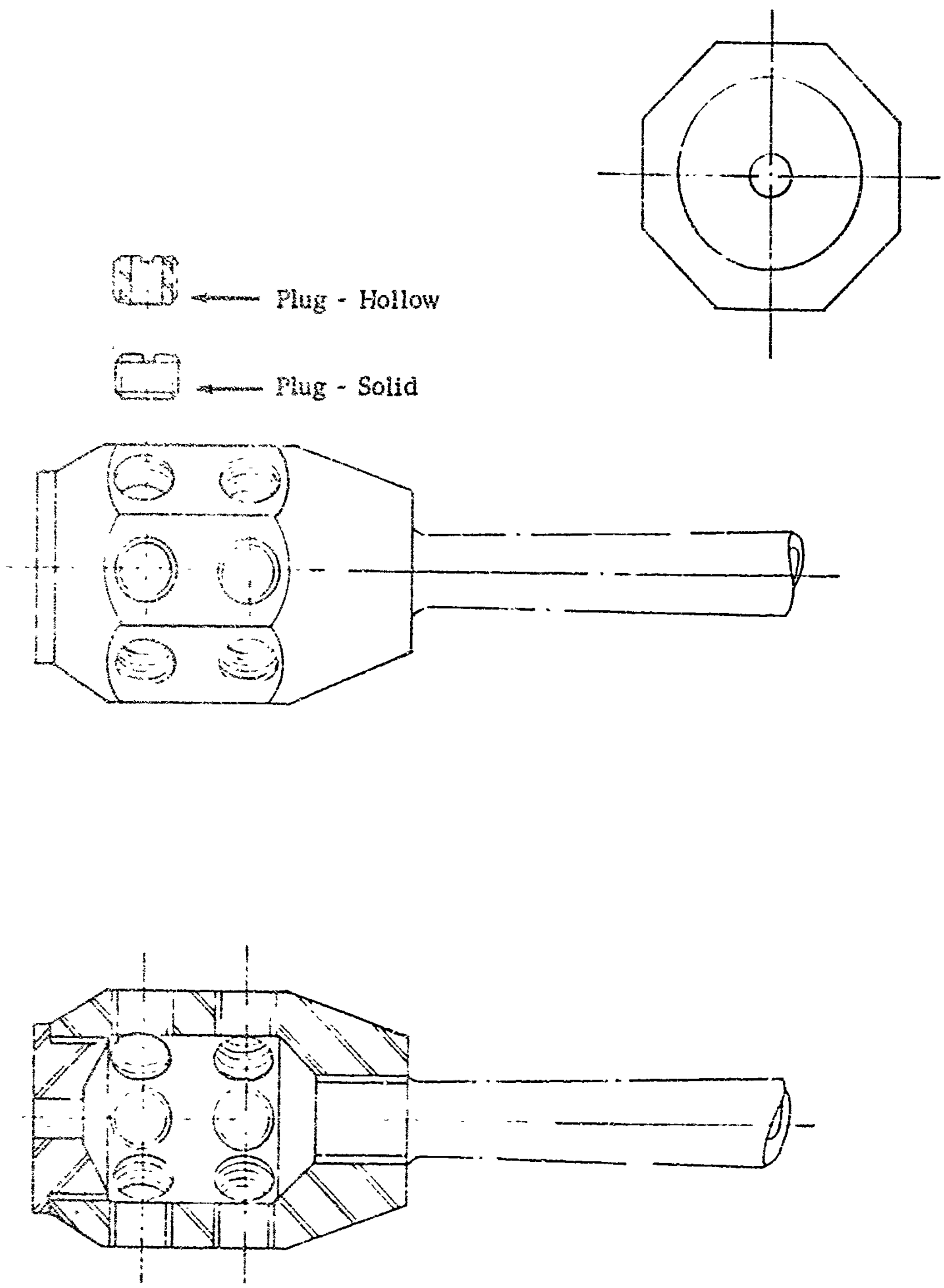


Fig. 4. Experimental Muzzle Brake,
with Adjustable Porting
(Scale - Full)

(U) Tests were conducted with the variable muzzle brake. Three or four expert shooters were used throughout testing.

(C) Since the tests were really of a trial-and-error nature -- as when varying the ports of the muzzle brake -- and since the criterion to which data were compared was 8 m extreme spread, no data were recorded when the dispersions achieved did not approximate 8 m extreme spread.

(C) Only the variable muzzle brake will be reported on herein, since it produced the best results, i.e., the least dispersion with little discomfort to the shooter (although all shooters wore V51R ear defenders).

(C) The tests and their results will essentially be listed, and data will be given when appropriate -- that is, either when the dispersions were close to 8 m extreme spread, or when needed to show differences between conditions.

(C) An angle-iron shaped like an inverted L, was attached to the butt plate of the AR15 to assure that the subjects' shoulder consistently contacted the same point of the butt plate. It had been found in previous studies that small variations in the distance between the point where the butt plate contacted the shoulder and the bore axis of the weapon created sufficient differences in overturning moments to cause large differences in dispersion for high impulse values.

(C) Test 1. Through trial and error, a combination of open and closed ports was selected to provide the "best fit" setting for three expert gunners in a standing offhand position, firing bursts of three rounds at a target range of 25 yards.

(C) The bullets were color-coded with lithographic ink so pattern configurations could be determined. The mean extreme spread for the three shooters was approximately 9 m. However, the data* describing each burst for each shooter for n trigger pulls was forwarded to Weapon Systems Laboratory, BRL, for a comprehensive measure of effectiveness.

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* (U) The horizontal and vertical coordinates for each round of each burst for each subject were provided BRL, along with means and standard deviations for each coordinate and, finally, the mean extreme spread for each subject.

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(C) It was found by BRL that the dispersion achieved by these gunners from the standing position for the same muzzle-brake deflector setting, with a long time-to-fire per trigger pull and with an L-shaped stock attachment (h=o), were comparable to the anticipated SPIW System.

(C) Since the results looked promising, another firing position, the kneeling-supported, was tried using the standing offhand muzzle brake setting. The dispersions were almost doubled and burst-to-burst variability increased considerably. For example, the same subject might score as low as 12 ṁ on one trigger pull and as high as 20 ṁ on the next. Since the dispersions were not near the 8 ṁ extreme-spread criterion, the approximate point below which marked increases in effectiveness result, no data were recorded.

(C) In reviewing the standing offhand data, it was noted that the mean radial distance between the first and second round was small -- approximately 5 ṁ -- and probably contributed heavily to the increase in effectiveness.

(C) As a result, Pilot Study Two was conducted to find, through trial and error, a "best fit" setting in the standing offhand position. The setting giving the least dispersion for a two-round burst was obtained. With this same setting, four experts fired from the standing- and kneeling-supported positions. The mean extreme spread in the standing position was 3 ṁ. In the kneeling position, the extreme spread was 14.8 ṁ.* Results are tabulated in Appendix.

(C) Limited prone firings were done with the same setting and, as expected, dispersion and variability increased, nearly double the kneeling firings, thus this data were not collected.

(C) Since the combination of muzzle brake deflector and L-shaped stock positioner would not give a sizeable increase in effectiveness for <u>all firing positions</u>, according to BRL, and since there was considerable variability between "best fit" muzzle brake deflector settings between individuals, even for the standing position, effort was directed toward trying to improve the three-round dispersion for all positions through design innovations.

* (U) The coordinates for each bullet for each trigger pull are available, if desired.

TABLE I

Conditions Tested with the AR15 (U)

Conditions	Date Fired	Mean Extreme Spread (inches)*	SD (inches)*
w/Pistol Grip, straight stock, w/o muzzle brake	Aug 23	55.89	5.98
w/o Pistol Grip, straight stock, w/o muzzle brake	Aug 23	59.83	4.22
w/o Pistol Grip, straight stock, w/o muzzle brake	Aug 17	56.11	6.8
Pistol Grip, straight stock, w/muzzle brake	Aug 21	24.83	13.0
Pistol Grip, straight stock, w/ muzzle brake	Aug 24	24.57	11.3
w/o Pistol Grip, straight stock, w/muzzle brake	Aug 17	23.31	10.1
w/o Pistol Grip, straight stock, w/muzzle brake	Aug 23	24.28	10.87
w/o Pistol Grip, w/o muzzle brake, w/wt, straight stock	Aug 23	41.22	5.21
w/o Pistol Grip, w/muzzle brake, w/wt straight stock	Aug 24	35.76	9.07
w/Pistol Grip, straight stock, w/muzzle brake, w/Pad	Aug 21	29.76	11.55
w/o Pistol Grip, straight stock, w/muzzle brake, w/Pad	Aug 21	29.8	10.52
w/o Pistol Grip, straight stock, w/muzzle brake, w/Pad and Spring	Aug 17	29.26	11.04
w/o Pistol Grip, straight stock, w/muzzle brake, Armor	Aug 21	26.43	8.73
w/Pistol Grip, no stock, w/muzzle brake	Aug 24	19.46	6.99

*Data in inches at 25 yards.

(U) The conditions listed below were tested:

a. The L-shaped stock positioner was removed, and the experimenters tried to attain the "best fit" muzzle-brake deflector combination. Variability between shooters increased.

b. A soft pad was added to the butt plate in an attempt to delay the force-time curve of the three rounds felt by the man.

c. A soft pad in combination with the stock positioner was tried

d. A spring was inserted between the butt plate and the rear of the bolt housing, as shown in Figure 5, in a further attempt to delay the force felt by the man This was tried alone and in combination with the pad and stock positioner Once again, the amount of braking and deflection were varied.

e. The stock was removed, and a cone-shaped rubber stop was attached to the rear of the bolt housing. In this way, it was thought that all forces would be in line, and no stock impositioning would result.

(C) All of the above were tried with expert shooters in all cases. The results were the same:

a. Large variability between shooters for the same setting, indicating that each man might have to make his own muzzle-brake deflector setting.

b. Either a common setting or each man's own setting would increase effectiveness for the standing position only.

c. In general, there did not appear to be any means of modifying the AR15 by adding a muzzle brake of reasonable efficiency to increase effectiveness for all shooters in all firing positions. Variables such as time to fire were not examined. But previous studies suggest that, even for the standing position, dispersion would increase as aiming error increased to combat-like errors of about 3.5 m, or when time to fire decreased.

(U) The AR15 was tested further to increase the fund of information about the effects of various rifle-design parameters on accuracy.

(C) The conditions of test and the average extreme spreads for three shooters are shown in Table 1. (If coordinates for each trigger pull are desired, they are available.)

(U) The tests described in this report were conducted by the Human Engineering Laboratories independently of any other testing of the AR15. The impetus for conducting these studies was based on the data derived from the Human Engineering Laboratories supporting research conducted on the SPIW program.

APPENDIX

Accuracy of Automatic Two-Round Burst Firing
For Two Firing Positions

KNEELING-SUPPORTED

Subject	Mean Horizontal Shift	Horizontal Standard Deviation	Mean Vertical Shift	Vertical Standard Deviation	Mean Extreme Spread*
A	2.6"	1.0"	11.8"	3.5"	12.3"
B	1.5"	3.3"	12.9"	2.5"	13.1"
C	0.8"	3.0"	13.9"	2.8"	14.0"
D	4.3"	5.6"	12.3"	2.3"	13.9"
All					13.3" (14.8 mils)

OFFHAND

Subject	Mean Horizontal Shift	Horizontal Standard Deviation	Mean Vertical Shift	Vertical Standard Deviation	Mean Extreme Spread*
A	0.4"	2.2"	-0.3"	1.9"	2.4"
B	1.0"	2.3"	2.7"	1.1"	3.4"
C	0.2"	1.4"	-1.2"	1.1"	1.7"
D	-0.2"	0.9"	-3.6"	2.2"	3.6"
All					2.7" (3.0 mils)

*Extreme spread is the distance between the two most widely dispersed shots of the three in a burst.

SUPPLEMENTARY

INFORMATION

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